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journal homepage: [www.elsevier.com/locate/iref](http://www.elsevier.com/locate/iref)Mixed duopoly with foreign firm and subcontracting<sup>☆</sup>Yuanzhen Lyu<sup>a</sup>, Jie Shuai<sup>b,\*</sup><sup>a</sup> Department of Finance, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong<sup>b</sup> Wenlan School of Business, Zhongnan University of Economics and Law, 182 Nanhu Ave., East Lake High-Tech Development Zone, Wuhan 430073, P.R.China

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## ABSTRACT

We consider a Hotelling model, in which a public firm competes with a foreign firm, at the mean time cooperates with it through subcontracting. We find that when there exists subcontracting, the presence of a foreign firm raises social welfare. Comparing to competing with the domestic private firm, when the public firm competes with the foreign firm, social welfare is lower, but consumer welfare is higher. And a variation in firms' costs or tariffs has no effect on either firm's location. Tariff on inputs raises domestic social welfare and government will charge an input tariff to the extent of costs difference. Tariff on final good has no effect on welfare but will raise prices and thus hurt consumers. Compared to no tariff at all, tariff on inputs alone raises retail prices, but tariffs on both inputs and final goods may reduce prices and raise consumer surplus.

## 1. Introduction

Due to the development of economies, relationships among different firms within the same industry are not restricted to competition anymore. They may also cooperate with each other. One important way of cooperation is subcontracting.<sup>1</sup> Subcontracting not only exists among private firms within the same country, but also exists among firms from different countries with different ownership. For example, First Automobile Works (FAW), a leading public firm in automobile industry in China, uses Toyota's engine VVT-i for its Hongqi HQ3, which is the engine used for Toyota's Crown Majesta at the mean time<sup>2</sup>. Chery Automobile Co. Ltd, also a public automobile enterprise in China, uses Mini-Cooper's engine Tritec for its Chery Amulet.<sup>3</sup>

As of today, subcontracting between a public firm and a foreign firm is very popular in developing and transitional economies. But to our best knowledge, there has been no literature on this subject yet, leaving several interesting questions to be answered: what is the welfare implication in presence of a public firm cooperating with a foreign firm? What is the effect of the cooperation on firms' strategies. What is the optimal tariffs and their effects on welfare?

To address these questions, we discuss a mixed duopoly model à la Hotelling, in which one public firm competes against a foreign firm and cooperates with it through subcontracting at the same time. We find that first, in consideration of subcontracting, the presence of foreign firm raises social welfare. This is in contrast to the case when there is no subcontracting, under which social

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<sup>1</sup> For some reasons such as technology advantages, cost advantages etc., one firm may subcontract part of production to its competitors. See Spiegel (1993) for examples. There are also other ways of cooperation, see for example (Liu, Mukherjee, and Wang, 2016).

<sup>2</sup> Technical parameters of Hongqi HQ3 and Crown Mejeata. Retrieved February 18, 2013 from [http://www.faw-hongqi.com.cn/](http://www.faw-hongqi.com.cn/http://www.faw-hongqi.com.cn/http://www.faw-hongqi.com.cn/) and <http://toyota.jp/crownmajesta/dynamism/engine/index.html>

<sup>3</sup> Jingyi Ma (August 19, 2012), Origin of Chery and Mini Sharing Tritec.

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welfare is unaffected by the foreign firm. Comparing to competing with a domestic private firm, when a public firm competes with a foreign firm, social welfare is lower but consumer welfare is higher. Second, the public firm is less aggressive in location if there is subcontracting. And comparing to competing with a domestic private firm, when competing with a foreign firm, the public firm is more aggressive in its location and pricing choice. It locates close to the center of the market while the foreign firm locates close to the end. Both firms' locations and market shares are independent of variation in tariffs or production costs. Third, tariff on intermediate good increases social welfare. Tariff on final good has no effect on social welfare but lowers consumer welfare. Tariff on both intermediate and final goods may actually lower retail prices and raise consumer welfare comparing to no tariff at all. This is in sharp contrast to existing studies (e.g. [Chao and Yu \(2006\)](#) and [Wang, Wang, and Lee \(2010\)](#)) which usually find that tariffs hurt consumers.

Our paper is related to the literature on mixed oligopoly markets. This strand of literature can be traced back to at least ([Merrill and Schneider, 1966](#)). Since then, many economists have contributed to different aspects of this field. Some literature focuses on the regulating role of the public firm in mixed oligopoly markets (e.g. [Harris and Wiens \(1980\)](#) and [Cremer, Marchand, and Thisse \(1991\)](#), [Matsushima and Matsumura \(2003\)](#), [Li \(2006\)](#)), some focuses on the privatization (e.g. [Anderson, de Palma, and Thisse \(1997\)](#) and [Matsumura and Matsushima \(2004\)](#)) or partial privatization (e.g. [George and La Manna \(1996\)](#), [Matsumura \(1998\)](#) and [Kumar and Saha \(2008\)](#)) of a public firm. Particularly, in a Hotelling model, [Cremer et al. \(1991\)](#) examine one public firm competes with  $n - 1$  domestic private firm and find that when  $n=2$ , the existence of the public firm can guarantee the first best equilibrium. Thus privatization of the public firm will hurt social welfare in such setup. This result is reversed in [Matsumura and Matsushima \(2004\)](#). In a mixed duopoly Hotelling model with endogenous cost differential through firms' cost reducing R & D, they find that privatization improves social welfare by mitigating the loss arising from excessive cost reduction investments. The key difference between our paper and the aforementioned two papers are the nationality of the private firm. The private firm(s) is domestic in their papers but foreign in ours. In the literature on mixed oligopoly markets with foreign firm(s) (e.g. [Matsumura, Matsumura, and Ishibashi \(2009\)](#), [Pal and White \(1998\)](#), [Chao and Yu \(2006\)](#), [Wang et al. \(2010\)](#), [Fjell and Pal \(1996\)](#)); [Heywood and Ye \(2009\)](#) use Hotelling type model to examine spatial price discrimination in presence of a foreign firm. Our paper uses a Hotelling type model to examine the mixed market with foreign firm too, but is different from theirs in several aspects. First, firms use a delivered price to discriminate consumers according to their locations in their model, while we use mill price and there is no price discrimination. Second, we focus on the subcontracting relationship, and provide formal analysis for the subcontracting and tariff.

Our paper is also related to the literature on subcontracting (e.g. [Kamien, Li, and Samet \(1989\)](#), [Spiegel \(1993\)](#), [Arya, Mittendorf, and Sappington \(2008\)](#) and [Andaluz \(2009\)](#)). Among these studies, the most related one is [Liang and Mai \(2006\)](#). They develop a variant of Hotelling's model with subcontracting to examine the principle of minimum differentiation. In their model, two spatially competing firms have different marginal costs, and the high cost firm can subcontract its input to the low cost firm. They find that if the ratio of transport rates between the subcontracted input and the final product is sufficiently large, the principle of minimum differentiation arises, otherwise the principle of maximum differentiation arises.

The rest of the paper proceeds as follows. Basic model is presented in [Section 2](#) and analyzed in [Section 3](#). [Section 4](#) contains the concluding remarks. Proofs of Lemmas and Propositions are presented in [Appendix A](#).

## 2. The model

Following the Hotelling model, we assume that there are two firms (1 and 2), each chooses a location  $x_i (i = 1, 2)$  for its final product over an interval  $[0, 1]$ . Without loss of generality, we assume that  $x_1 \leq x_2$ . There is a unit mass of consumers, whose preferences are uniformly distributed over the interval  $[0, 1]$ . Each consumer is assumed to buy exactly one unit of final product from either firm, and her utility loss of buying a not perfectly matched product (transport cost) takes a quadratic form. For example, consider a generic consumer located at  $x$ , her utility of buying from firm 1 and 2 are respectively:

$$u_1 = V - p_1 - t(x - x_1)^2, \quad u_2 = V - p_2 - t(x - x_2)^2,$$

where  $t$  is transport cost coefficient,  $p_i (i = 1, 2)$  is firm  $i$ 's price, and  $V$  is consumers' reservation price. It is readily shown the marginal consumer's location is:

$$\hat{x} = \frac{p_2 - p_1}{2t(x_2 - x_1)} + \frac{x_1 + x_2}{2}.$$

Firm 1 and 2's demands are then respectively:

$$q_1 = \frac{p_2 - p_1}{2t(x_2 - x_1)} + \frac{x_1 + x_2}{2}, \quad q_2 = 1 - \left( \frac{p_2 - p_1}{2t(x_2 - x_1)} + \frac{x_1 + x_2}{2} \right).$$

The two firms use an intermediate input to produce a final product. For simplicity we assume that firms employ one unit of input to produce one unit of final good. Firms' costs of producing final goods are the same, which we normalize to zero for simplicity. Their costs of producing input are different. Firm  $i$  produces input with a constant marginal cost  $c_i$ . Without loss of generality, we assume that  $c_1 \geq c_2$ . We assume that public firm is firm 1 and foreign firm is firm 2, so it is consistent with practice.

The foreign firm may produce its inputs and/or final goods either within the country or outside the country. In the latter case, the foreign firm needs to import the input and/or final good into the country, and the domestic government can charge a per unit tariff on the imported objects. The per unit tariff on input is denoted by  $t_m$ , and tariff on final goods is denoted by  $t_f$ .

Due to the cost difference, the public firm may subcontract out the production of input to the foreign firm. In this case, the public

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